

Chapter 5

Irrigated Lands Management Practices

Irrigated Lands Management Practices

Management practices, best management practices and management measures are all various ways of describing how growers and other responsible parties pursue stated objectives. In some cases a practice, or group of practices are pursued solely to lower production costs. In other cases, practices are implemented to address a specific objective, such as a reduction storm water discharge that is external to the growers operation.

Actions taken to prevent or reduce impacts to water quality include physical and operational (management and policies) changes as well as educational efforts. Physical changes include the modification of irrigation and drainage systems at both the on-farm and district level. Typically infrastructure improvements are accompanied by operational or management changes. At the district level operational changes include implementation of delivery policies that enable more flexible on-farm use and restrictions on return flows and drainage. At the farm level there are a great number of actions that can be implemented to reduce impacts to water quality and these are discussed in further detail in the following section of this report.

The irrigated lands section of this chapter begins with a discussion on the constituents of concern and then addresses known and potential management practices that can potentially impact them. In addition there is a review of the status of management practice information from the coalitions and ongoing state agency level grant, research and information programs.

The managed wetlands section of this chapter is organized by subbasin within each of the Central Valley watersheds. For each subbasin there is a general discussion about the private wetlands and a detailed discussion about the state and federal wetlands. The reader should note that there is considerably more pertinent information available for the wetlands managed by public agencies than for the private wetlands or the agricultural areas. The disproportionate level of available information is due to the fact that private landowners generally do not collect nor do they feel comfortable releasing this type of information.

Water Quality Constituents

Improving water quality is based on reducing or eliminating constituents that impact beneficial uses. The constituents that are addressed in this baseline survey vary by watershed but are categorized as follows.

- Sediment—Transported and deposited particles or aggregates derived from rocks, soil or biological material. There are two primary concerns for sediment: its ability to bind chemicals, and the physical impacts caused by deposition.
- Pesticides—Natural or synthetic chemicals used to kill pests and unwanted vegetation.
- Nutrients—Natural or synthetic elements or compounds that are essential materials for organism growth and development.
- Native—compounds resulting from use of land and water resources. In the Central Valley the primary native constituents of concern include boron, selenium, dissolved organic carbon (DOC) and salinity.

The responsibility to track, monitor and regulate water quality constituents falls on several state and federal agencies. The main agencies include the DPR, the State Water Board and the EPA. Responding to the EPA these state agencies implement several efforts. The DPR through regulating pesticide sales and use and fostering reduced-risk pest management protects human health and the environment. The State Water Board under Section 303(d) of the CWA, is required to develop a list of impaired surface water bodies. In addition the CWA requires that the State Water Board establish priority rankings for water bodies on the lists and develop action plans, called TMDLs, to improve water quality.

In 2003 the DPR listed 354 active ingredients applied in pesticides. This listing covers all pesticides used in California for any purpose including irrigated agriculture. In addition to the compounds listed, the total amount used is also provided. Detailed information for these constituents is available on geographic, constituent and crop use basis at <http://calpip.cdpr.ca.gov/cfdocs/calpip/prod/main.cfm>. In addition to the listing of pesticides used there are links for product information, research and use trends.

The State Water Board lists water bodies that are impaired for beneficial use by pollution and publish them on the 303d list. For 2002 the Central Valley listed around 124 impairments that are potentially caused by irrigated agriculture. The main pesticide constituents of concern and the crops they are primarily used on are listed in Table 5.1. In addition to pesticides the 303d lists impairments caused by native constituents, nutrients and temperature.

Table 5-1. Pesticides Listed on the CWA Section 303(d) List That Are Commonly Used in Agricultural Production in the Central Valley of California

[illegible]

Behavior of Water Quality Constituents

Each constituent has unique chemical and physical properties and responds differently to biological activity; therefore, constituents can move and remain effective in different ways. These properties - volatility, adsorption, persistence and solubility are discussed below.

- **Solubility**—This is the amount of constituent that can dissolve in water. Highly soluble constituents dissolve in and flow with water and are often referred to as mobile constituents. Therefore, the movement of pesticides with water is increased with more soluble products.
- **Adsorption**—This is the attachment or adsorption of a pesticide or nutrient to a soil particle. The strength of attachment varies by constituent type. Constituents that are attached to soil particles will move with the particle.
- **Volatilization**—This is the process of a substance changing from a solid or liquid to a vapor. The volatilization of a constituent is a function of the constituents' chemical properties and its exposure to environmental factors such as relative humidity, temperature and wind speed. For example, low relative humidity, high temperatures and high wind speed favor volatilization.
- **Persistence**—This is the ability of the constituent to remain in the environment for long periods of time. Many constituents are stable in the environment and have particularly long half-lives while other constituents are more readily converted to their breakdown products through microbial degradation, hydrolysis, or through thermal processes.

Based on their properties, constituents can move from the place of application in three basic ways—moving with surface water runoff and entrained soil particles, moving through percolation into the groundwater, and moving with air flow as drift. The following is a summary of the ways in which constituents move.

- **Moving with runoff and soil particles**—soluble constituents will move with runoff and can impact the receiving water body. Constituents adsorbed to soil particles can be transported from the place of application on sediments and can impact the receiving water body.
- **Deep percolation**—this is the movement of constituents into the groundwater. Soluble constituents can move as either surface runoff or percolation to groundwater. While adsorbed constituents do not move easily to groundwater, persistent adsorbed constituents can move to groundwater and cause more serious long-term contamination issues. DDT is an example of a persistent legacy pesticide that adsorbs to soil particles and can be found in groundwater.
- **Drift**—this is the movement of a constituent as either a vapor or as particles. The primary factor causing drift is the method of application and the environmental conditions when the constituent is applied.

Constituents in runoff and adsorbed to sediment can impact receiving waters. Factors that affect the movement of constituents to surface waters include the timing of rainfall or irrigation following an application, slope, and the type of soil covering. Constituents can impact groundwater either directly or indirectly. Direct or point source impacts occur due to site-specific spills or preparation areas. Indirect or nonpoint-source impacts occur due to deep percolation on areas where the constituent is applied or from surface water flows to groundwater.

Existing Management Practices

In general, the movement of constituents from the place of application to receiving water is through water management actions. Two primary actions lead to increased surface runoff; district operations and surface irrigation methods. To improve district operations, investments are made in regulating reservoirs, canal automation, interceptor systems and increased labor. These actions give a water supplier greater control over its operations and allows the end user to better match their crop water needs with the available supply. Although district improvements are not implemented to improve water quality they do have a direct impact on the ability for the end user to manage their system to reduce impacts to water quality. Similarly, end users are investing in technologies that utilize district improvements and provide greater control over the use of water. These technologies generally result in higher uniformity that in turn reduces the impacts to water quality from nutrients and pesticides. In addition, the higher level of management used with these systems typically results in less surface runoff.

The CWA requires development of TMDLs for all impaired water bodies. Under the TMDL program, the Board must set waste load allocations for nonpoint source dischargers and develop an implementation program that will meet these allocations. Irrigated return flows and storm water from irrigated land is a major source of several of the constituents being addressed by the TMDL program.

In January 2000, the State Water Board made public and submitted to the Legislature, the Plan for California's Nonpoint Source Pollution Control Program (NPS Program Plan), pursuant to Section 13369. On May 20, 2004, the State Water Board adopted the Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program (NPS Implementation and Enforcement Policy). The NPS Implementation and Enforcement Policy provides guidance to the RWQCBs on how to develop, structure and enforce an NPS pollution control program.

An NPS pollution control implementation program is a program developed to comply with State Water Board or RWQCB WDRs, conditional waivers of WDRs, or basin plan prohibitions. They may be developed by a RWQCB, the State Water Board, an individual discharger, or by or for a coalition of dischargers in cooperation with a third-party representative, organization, or government agency.

Pursuant to the NPS Program Plan, the Regional Boards must implement programs to ensure that dischargers are following specific management measures. There are management measures that apply to discharges from irrigated agriculture, including specific steps for erosion and sediment control, nutrient management, pesticide management, and irrigation water management. Under this program, the manager of an irrigated field is expected to follow appropriate management practices designed to control potential releases of multiple pollutants. It is incumbent on the individual landowner or farmer to implement these programs, as the Central Valley Water Board is required under the NPS Implementation and Enforcement Policy to take enforcement actions on individual landowners or operators and cannot take enforcement actions against third party implementation groups.

Crop type, physical setting, and economics drive the selection and implementation of management practices used to support production systems. For a given crop rotation the physical setting, primarily water availability and the slope of the land are major drivers in selecting the type of on-farm irrigation and drainage system to use. The selection of other practices such as cover cropping, nutrient and pesticide management, harvesting and cultivation are driven by economics. County level agricultural extension offices typically provide publications that cover crop specific management practices and can be accessed through <http://ucanr.org/ce.cfm>.

The initial scope of this effort was to review existing data and information pertaining to on-going irrigated agriculture management practices directed at improving water quality. After a review of documents, web searches and multiple phone conversations, it was apparent that there is very little quantitative or qualitative information regarding ongoing water quality-related management efforts. The information that is readily available is primarily written guidance on appropriate management practices based on cropping, cultural practices and irrigation water management. Given that there are over 200 crops grown in the Central Valley with most crops amenable to several different types of production systems the combination of management practices is significant and potentially daunting. However, the category of management measures, identified by the State Water Board provides a consistent framework for a general discussion about practices.

Because little information is readily available to describe practices that are actually being used in the field, a decision was made to contact local representatives from the water quality coalitions, county agricultural commissioners, the Natural Resources Conservation Service and resource conservation districts. Each individual contacted was provided an explanation of this documentation process followed by a few questions regarding on-going management practices. Specifically, they were asked if there are reports, databases or other resources that provide quantitative or qualitative information about ongoing irrigated agriculture management practices designed to reduce impacts to water quality. Information was requested for erosion and sediment control, nutrients, pesticides, grazing and irrigation water management, and education and outreach. Although all of the individuals contacted understood the need for the information, very little quantitative data is available. Individuals that

worked with the coalitions responded that they were aware that the information is required for the environmental documentation and that the coalitions are responsible for collection and reporting this information. In addition, all individuals contacted stated that crop producers in their area are implementing multiple management practices; however, it is the extent of the implementation of those practices that is not known.

The following is a list of who was contacted and a summary of the discussion.

Sacramento Valley Water Quality Coalition

Aaron Ferguson—Northern CA Water Association (NCWA). Aaron provided a copy of the coalition's comprehensive report on the evaluation of commodities and appropriate management practices for each commodity.

Paul Robins—Yolo County Resource Conservation District. Paul stated that the coalition is working on an inventory of existing practices but nothing is available at this time.

Alan Fulton—Glenn County Agricultural Commissioner. Alan stated that his agency does not maintain that type of information. He suggested a review of the Integrated Pest Management database for information on management practices by pest control advisors and individual growers. Another potential source of information on the implementation of water management practices is the DWR land use database that tracks the conversion of croplands converted from surface irrigation to micro or drip irrigation.

California Rice Commission

Tim Johnson—California Rice Commission. In November 2004 the California Rice Commission provided the Central Valley Water Board with its quality assurance project plan (QAPP) to meet the requirements of Central Valley Water Board resolution R5-2003-0105, conditional waiver of waste discharge requirements. This document describes in detail the steps taken by rice growers to manage constituents. The document provides an inventory of the acreage under monitoring but does not provide an analysis of acreage participating in the management practices.

Southern San Joaquin Valley Water Quality Coalition

Dawn Wells—Kings River Conservation District. Dawn stated that they are responsible for collecting the information but have not started. She estimates that the information will not be available until spring of 2006.

East San Joaquin Water Quality Coalition

Perry Klassen—Coalition for Urban/Rural Environmental Stewardship (CURES). CURES has a BMP survey that was conducted in 2001 with a follow up in 2004. The information is available; however, it was not received in time for this report.

Teri Murrison—Merced River Watershed Coordinator. Teri stated that they did not currently have the information but that they are planning to collect it in the near future.

Goose Lake Coalition

Kim Wolfe—Modoc County. In Modoc County, the coalition does have information regarding protection of riparian areas within grazing lands; however, it was not available in time for this report.

Root Creek Water District

Kevin Johanson at Provost and Prichard Engineering. This coalition is small and the overhead to operate is greater than the available funding. The coalition did survey its members regarding their management practices however the data has not been analyzed. At this point some of the growers are signing up with the Eastside San Joaquin Coalition. Although nearly all growers are on microirrigation systems they did have a toxic hit in February 2005, resulting from storm water runoff, from an unknown compound.

San Joaquin Valley & Delta Water Quality Coalition

Dan Sisnowski—San Joaquin County Agricultural Commissioner. Dan stated that a limited amount of information on management practices is sent to the Agricultural Commissioner's office; however, they do not maintain the information in an organized manner.

John Meek—San Joaquin County Resource Conservation District. No response.

Westlands Water District

Thad Betner—Westlands Water District. Westlands does not have a reporting mechanism for agricultural practices information. Westlands works with growers when runoff occurs. They have an active on-farm loan program that provides \$4 million annually for the installation of drip and micro irrigation systems. These systems are primarily being installed on the hilly western area of the district. The loan funding and privately financed installations cover about 8,000 acres per year.

Westside San Joaquin River Watershed Coalition

Joe McGahan—Summers Engineering. Joe provided a copy of their coalition watershed evaluation report. This report lists the management practices that are used within the coalition but there is no quantification of the efforts.

The Grasslands Bypass effort utilizes a highly coordinated and monitored system to optimize discharge of wastewater with elevated levels of salinity and selenium. In addition, there is considerable documentation of the efforts of the Grasslands Bypass that is accessed through <http://www.usbr.gov/mp/grassland/>. This effort regulated through use of a waste discharge requirement and lands included in this project are not subject to the current conditional waiver.

Although there is little quantitative information on the extent of known management practices, there is a considerable amount of information on proven practices. In general the connection between practices and outcomes is known however there is very little information regarding the specific benefits of the implementation of practices. For example in controlled studies the use of cover cropping has been shown to reduce the amount of sediment running off a

production field. However when this practice is implemented, by growers, its effectiveness can only be estimated—unless appropriate monitoring is involved.

Discussion of Known and Proven Practices

Guidance information regarding management practice is available in numerous formats from a multitude of sources. Information is available for site-specific issues such as reduction of erosion in the Yolo Basin or alternative strategies for application of annual dormant spray on tree crops. Other information is broad reaching such as the use of pressurized irrigation systems over surface irrigation methods. The reader should note that in some instances management practices could also be considered a treatment process. A good example of this is the use of tailwater ponds to capture and reuse surface runoff. Properly managed this practice can eliminate sediment in discharge waters and serve as a holding basin for storm water runoff that may contain dormant spray residue. Another consideration for the implementation of practices is the redirected impacts that may occur. For example the use of cutback irrigation to reduce surface runoff may result in greater impacts to groundwater.

The following is summary of management practices that are implemented to reduce impacts to water quality. The initial section covers known practices followed by a discussion of proven practices by management measures categories. Also, the individuals interviewed for each coalition acknowledged most of the management measures discussed below.

Known Practices

This section covers the extent of known actions that potentially contribute to a reduction in the impact to surface water quality. The most quantified sources of this information are the NRCS Environmental Quality Incentive Program (EQIP) effort and the California Rice Commission. The NRCS provides funding for the implementation of management practices through the EQIP. This program is implemented at the county level and provides a direct cost share to growers implementing management practices that are designed to achieve a desired outcome.

Table 5-2 provides a regional listing of EQIP practices that potentially contribute to a reduction in water quality impacts for 2002. This information is a subset of the statewide EQIP effort that is based on a compilation of county level efforts. Because the information is based on the county level it cannot be assigned to a specific water coalition but rather into a general region. The data provided for each practice reports the count of the number of projects funded and the sum of the units implemented. For example the first practice listed, *conservation cover* (which is the establishment and maintenance of permanent vegetative cover to protect soil and water resources), had five separate actions covering 13 acres, all in the Sacramento Valley.

Table 5-2. Partial Listing of NRCS Conservation Practices that Received EQIP Funding in 2002

Practice	Data	Region (May Include Multiple Coalitions)				Grand Total
		Delta	Sacramento Valley	SJV North	SJV South	
Conservation Cover-(ac.)	Count	0	5	0	0	5
	Sum	0	13	0	0	13
Controlled Drainage-(ac.)	Count	0	1	0	0	1
	Sum	0	44	0	0	44
Cover Crop-(ac.)	Count	5	22	1	51	79
	Sum	56	997	75	2,565	3,693
Dike-(ft.)	Count	0	4	0	0	4
	Sum	0	11,330	0	0	11,330
Diversion-(ft.)	Count	1	3	0	0	4
	Sum	1,800	1,000	0	0	2,800
Field Border-(ft.)	Count	0	3	0	0	3
	Sum	0	2,475	0	0	2,475
Filter Strip-(ac.)	Count	1	3	0	0	4
	Sum	2	3	0	0	5
Grade Stabilization Structure-(no.)	Count	1	12	0	0	13
	Sum	2	5,302	0	0	5,304
Grassed Waterway-(ac.)	Count	1	3	0	0	4
	Sum	1	3	0	0	4
Hedgerow Planting-(ft.)	Count	1	14	0	3	18
	Sum	1,000	3,358	0	3,960	8,318
Improved Water Application-(ac.)	Count	0	0	1	0	1
	Sum	0	0	38	0	38
Irrigation Land Leveling-(ac.)	Count	13	1	0	4	18
	Sum	894	10	0	255	1,159
Irrigation System-Microirrigation-(ac.)	Count	9	5	30	16	60
	Sum	2,905	185	30	692	3,812
Irrigation System-Sprinkler-(ac.)	Count	7	2	4	1	14
	Sum	7	2	4	1	14
Irrigation System-Surface & Subsurface-(no.)	Count	0	2	0	0	2
	Sum	0	2	0	0	2
Irrigation System-Tailwater Recovery-(no.)	Count	10	7	19	3	39
	Sum	10	7	24	3	44
Irrigation Water Conveyance - Ditch and	Count	2	1	0	0	3
	Sum	4,940	2,000	0	0	6,940
Irrigation Water Conveyance - Pipeline -	Count	19	53	37	49	158
	Sum	50,810	157,386	147,849	114,167	470,212
Irrigation Water Management-(ac.)	Count	19	83	0	44	146
	Sum	1,372	6,006	0	2,582	9,960
Land Grading-(ac.)	Count	0	1	0	0	1
	Sum	0	1,000	0	0	1,000
Lined Waterway or Outlet-(ft.)	Count	0	1	0	0	1

Practice	Data	Region (May Include Multiple Coalitions)				
		Delta	Sacramento Valley	SJV North	SJV South	Grand Total
	Sum	0	150	0	0	150
Nutrient Management-(ac.)	Count	1	73	0	52	126
	Sum	158	5,247	0	2,928	8,333
Pest Management-(ac.)	Count	13	132	5	68	218
	Sum	809	5,239	960	3,934	10,942
Pipeline-(ft.)	Count	8	52	2	11	73
	Sum	17,050	75,491	1,900	25,410	119,851
Pond-(no.)	Count	0	10	0	3	13
	Sum	0	20	0	3	23
Precision Land Forming-(ac.)	Count	0	4	0	0	4
	Sum	0	59	0	0	59
Pumping Plant for Water Control-(no.)	Count	2	6	0	4	12
	Sum	2	7	0	5	14
Residue Management, Mulch till-(ac.)	Count	9	9	0	0	18
	Sum	1,606	1,081	0	0	2,687
Residue Management, No-till & Strip Till-	Count	0	7	0	0	7
	Sum	0	553	0	0	553
Residue Management, Seasonal-(ac.)	Count	0	3	0	0	3
	Sum	0	187	0	0	187
Row Arrangement-(ac.)	Count	1	0	0	0	1
	Sum	158	0	0	0	158
Sediment Basin-(no.)	Count	0	3	6	0	9
	Sum	0	1,669	6	0	1,675
Soil Salinity Control-(ac.)	Count	0	0	0	5	5
	Sum	0	0	0	624	624
Structure for Water Control	Count	1	20	0	1	22
	Sum	1	53	0	2	56
Subsurface Drain-(ft.)	Count	1	0	0	1	2
	Sum	3,000	0	0	18,040	21,040
Underground Outlet-(ft.)	Count	0	6	0	0	6
	Sum	0	1,830	0	0	1,830
Waste Storage Facility-(no.)	Count	2	13	6	0	21
	Sum	2	14	6	0	22
Water & Sediment Control Basin-(no.)	Count	1	0	0	0	1
	Sum	2	0	0	0	2
Water Well-(no.)	Count	4	6	1	1	12
	Sum	4	6	1	1	12

Listed practices are those that have the potential either directly or indirectly to contribute to reduced impacts to surface water quality. Listed practices account for \$6.5 of the \$16 million spent in California in 2002.

The level of detail presented in Table 5-2 is only available for 2002. Practice level data for prior years is unavailable and data for subsequent years has not been analyzed or posted to the NRCS website. What is known for other years is

the level of EQIP effort (Table 5-3). The EQIP funding priorities change annually therefore it is not possible to estimate the types of practices implemented in other years. Although the NRCS provides guidance for implementation and estimation the benefits of each practice there is no repository of information that reports the benefit.

Table 5-3. Total California EQIP Funding for 2000–2005

EQIP Funding Categories with Potential to Meet Water Quality Objectives	NRCS California EQIP Funding Allocations (\$ million)						Local Share ² (\$ million)	Total (\$ million)
	2000	2001	2002	2003 ¹	2004 ¹	2005 ¹		
Statewide Ground and Surface Water Conservation Initiative				9.9	9.2	9.1	112.4	140.5
Regular EQIP				17.2	26.0	29.7	291.3	364.1
Subtotal	5.8	22.7	16.0	27.0	35.1	38.8	403.6	504.5
Coalition Area Funding based on 2002 analysis ³	2.3	9.2	6.5	11.0	14.3	15.7	164.0	205.0
Other EQIP Funding: NOT CONSIDERED								
Klamath Basin Ground and Surface Water Conservation Initiative				5.5	4.8	4.0		
Diesel Engine Replacement Program				3.5	0.7	0.7		
Air Quality Initiative				2.0	4.8	4.3		
Other				0.6		0.5		

¹ This data taken from initial allocations, actual data may change.

² Local share is assumed at 75% of total project cost.

³ See Table 5-2 for 2002 analysis.

The California Rice Commission reports that the in the past, almost all rice farms were irrigated with conventional flow-through systems where water flows into one check or basin and then to the next check. Finally, the water flows out of the bottom check and into a drain. The flow through nature of conventional water management systems has made it increasingly difficult for rice growers to comply with the required water-holding periods that are designed to reduce pesticide residue.

Closed systems, such as the recirculating and static systems, are considered to be best management practices for holding treated water because they can reduce pesticide residue mass discharge by up to 97% over conventional systems. In recirculating systems, water is pumped from the bottom check back to another field or check. Some of these systems have been implemented at the irrigation district level, but most were built by individual farming operations. A static system independently controls inflow into each basin and limits it to the amount required to replenish applied water lost to evapotranspiration and percolation.

Static system substantially reduces the possibility of spillage of field tailwater into public drains.

In an effort to improve the water quality of rice field drain water growers are adopting closed systems. According to the California Rice Commission the four major rice growing counties (Colusa, Glenn, Yolo, and Butte) show an increase in the use of closed system from 74,600 acres in 1991 to 136,200 acres in 1994. However, the total number of acres in rice production also increased during the same time period. Of the total acreage, closed systems increased from 31.8 to 36.5% between 1991 and 1994, while conventional systems decreased from 68.2 to 63.5%.

Proven Practices

This section provides a summary of the management and hardware actions that are known to provide a water quality benefit. The practices are presented by the State Water Board identified management measures categories. The single most comprehensive reference for practices is the NRCS. This resource lists over 100 proven practices that provide information for physical actions that apply to several of the management measure categories. Although the NRCS guides were developed for general use they contain sufficient guidance for local implementation.

In nearly all cases there is no quantified information regarding the amount of benefit received from implementing the action. However, where quantified information is available it is provided. When reviewing this section one is advised that the application of any action will be specific for the site and how the action is managed. Therefore the potential outcome of any action cannot be guaranteed.

Erosion and Sediment Control

Practices in this category are designed to prevent the movement of soil aggregates into receiving waters. The basic strategy is to slow the water down to a point where soil aggregates settle out or to prevent soil aggregates from entering into irrigation water. Retaining soil aggregates through the use of cover cropping or mulching prevents sediment movement into irrigation water. Increasing infiltration also reduces runoff and movement of soil aggregates. Another approach to reducing the offsite movement of soil aggregates is to physically stop the sediment through filter strips, laser leveling fields, sediment traps, vegetated waterways, windbreaks and polyacrylimides. The Yolo Resource Conservation District (RCD) (Yolo RCD 2002) found that the use of cover cropping reduced sediment loading by 46% than a follow field. Another finding by the Yolo RCD was that sediment traps captured between 60 to almost 90% of suspended sediment. Specific practices that have been implemented at some level include:

- **Water and Sediment Control Basins**—Constructed earth embankments or a combination ridge and channel. Constructed across slope and minor watercourses to form a sediment trap and water detention basin.
- **Install temporary water checks**—these can be placed on the head or tail end of the field with the primary purpose of slowing down water.
- **PAM applications**—polymers added to irrigation water at the head end of a field supply ditch or discharge point. Applications of 5-8 lbs/acre are typically metered with a gandy-type applicator. Several field trials have shown a 95% reduction in erosion from the use of PAM.
- **Tailwater return systems**—essential large catchments ponds that prevent the movement of sediment off-site. These are typically located at the low point in the field and if used to trap sediment they must be maintained. These systems can also provide improved water management.
- **Tailend berms**—Constructed earthen berms that slow down water allowing sediments to settle out. These can replace tail-end “v” ditches.
- **Sediment traps**—this is a variation on tailwater pond and berms. These are typically located on the tail end of a field and must be maintained.
- **Enhanced field drains**—by increasing the weir length the velocity slows down allowing sediments to settle out before discharge.
- **Cultural practices**—These are practices that growers use to manage cropping systems. Cultural practices involve tillage operations such as planting, ripping, weed control, plowing, ripping, disking, aerating, and harrowing. These practices are designed to loosen soil, direct water flow, and encourage vegetation growth. If properly conducted, tillage can dramatically reduce runoff and increase infiltration. The effects of tillage on offsite sediment movement depend greatly upon the specific tillage technique used, soil type, slope, soil organic matter, and a number of other site specific factors. Improper tillage can also compact soil, reduce soil organic matter, damage soil structure, reduce the amount of tillage during the irrigation and storm water season. Breaking up soil aggregates makes fines more available to move with the water.
- **Vegetated drainage systems**—Vegetated drainage ditches can be incorporated into a management program to help prevent offsite movement of sediments, nutrients and pesticides with return flow and storm water runoff. This involves using drainage systems that are a part of existing agricultural landscape features. Various vegetation management practices have the potential to reduce pesticide runoff by increasing soil infiltration, accelerating pesticide degradation at the soil surface and preventing the offsite movement of soil, nutrient, and pesticides during winter storm events.
- **Irrigation system hardware**—The type of irrigation system chosen is the result of many factors including crop type and rotation, topography, water supply, soil type, delivery system capabilities and cost. The type of irrigation system used along with its management can determine the potential for surface runoff and the amount of sediment running off a field. There are three main types of irrigation systems: surface, sprinkler and microirrigation.

Under proper management there is usually little or no runoff with sprinkler and microirrigation systems.

Surface irrigation has the most potential for reducing the impacts to water quality through a reduction in runoff. Although some surface systems require runoff to achieve uniform distribution structures (such as tailwater recovery systems discussed above) can be put in place to increase efficiency, reduce runoff and trap sediments. Other surface irrigation practices that can reduce runoff include:

- **Level basins**—for high irrigation uniformity these systems require large flow rates however there is no surface runoff from these because there is no outlet or drain. Although this is an efficient method of irrigation, due to the high flow rates required it would be difficult to convert existing systems to these.
- **Surge irrigation**—these system advance the wetting front down furrows by pulsing the water. The objective is to optimize the infiltration rate and reduce surface runoff. These systems require that there are multiple areas to divert the water.
- **Cutback irrigation**—once the irrigation water has progressed a pre-determined length of field a cutback in flow rate is made. Although this takes more field labor the cutback step reduces the total volume of runoff and slows the water down allowing sediment to fall out.

Nutrient Management

The basic practice in this category is to use a nutrient management plan to optimize the use of nutrients. This plan should identify the physical boundaries and features of the field, maintain records about the existing nutrient resources within the field and identify the nutrient needs of the crop. When planning the use of nutrients, consideration needs to be given to the timing of application to ensure that the rate of application meets the crop needs and does not lead to leaching losses or field runoff. A nutrient management plan should address the following:

- **Nutrient sampling in soil, tissue and water**—determine the amount of nutrients in soil and water for early season applications. Use plant tissue sampling for mid and late season nutrient decisions.
- **Timing of applications**—base nutrient applications on existing nutrient levels and crop nutrient requirements. Optimize nitrogen applications to periods of crop uptake.
- **Fertilizer placement**—place fertilizer material where maximum plant uptake occurs
- **Water management**—utilize micro or sprinkler when applying fertilizers, practice cutback, surge or tailwater recovery when using surface methods.
- **Vegetation**—planting grassed waterways and ditches can help remove sediments along with attached nutrients and pesticides. Increased vegetation,

including cover crops, can uptake nutrients and prevent them from moving to surface and groundwater.

- **Application practices**—maintain equipment and calibration, use backflow prevention devices when applying through water, distribute wash water, cleanup spills.

Another promising management practice for nutrients is the implementation of precision farming. This practice utilizes various tools to tailor the nutrient, water and cultural practices required for crop production. Precision farming requires that the lands be mapped and managed on a scale that provides an economic return. For example if a field has both a sandy texture and a clay, the sandy soil will require more frequent, light irrigations than a heavy clay. Customizing the irrigation schedule will reduce the potential for nutrient leaching on the sandy texture.

Pesticide Management

The objective of this practice is to reduce the contamination of surface and groundwater from pesticides. The basic approach is to determine pesticide needs based on control needs, crop type and previous control approaches. Appropriate methods of use need to be followed for mixing, application and clean up. In addition, proper irrigation water management and erosion control are needed to prevent constituents from moving to groundwater or surface water.

A major tool that is continually refined is integrated pest management (IPM). IPM is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through monitoring and a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties of crops. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment.

Conventional pesticide application technologies such as sprayers are designed for ease of use, and not for efficiency. According to the Central Valley Water Board, sprayer studies in orchards show that 40% to 60% of the applied spray goes to the orchard floor, while only 9% to 16% ends up on the trees. Aerial pesticide application can also result in a direct drift to surface waters. Volatilization and atmospheric transport of pesticides are likely to affect surface water quality according to a USGS study (USGS 2002) that documented atmospheric deposition as a transport mechanism during runoff events when precipitation and surface runoff are major sources of stream flow. Several studies by the Sacramento River Watershed Program report that the use of cover cropping reduced pesticide runoff. In one study (Ross et al. 1997) cited by Lee 2002 there was as a 74% reduction in pesticide runoff from a peach orchard over an orchard with no cover cropping.

- **Integrated pest management**—the UC Davis website <<http://ipm.ucdavis.edu>> provides extensive information on how to utilize IPM. In addition the activities listed below are a component of IPM.
- **Monitoring**—this requires qualified field personnel to monitor the orchard or field for pests so that treatments are based on need rather than the calendar.
- **Labeling**—read and follow all labeling instructions. The Department of Pesticide Regulation provides guidance for how to interpret labels however registered pesticides contain full instructions on how to apply the chemicals.
- **Dormant spray**—altering the use of organophosphate (OP) and non-OP sprays helps to prevent resistance in the target pests. There is considerable information on this topic at <<http://www.curesworks.org/bmp/almondDormant01.asp>>. Other dormant spray practices:
 - ❑ Restrict applications to ground based only.
 - ❑ Do not apply with 100 feet upslope of any sensitive aquatic habitat.
 - ❑ Maintain a 10-foot wide vegetative buffer strip from edge of field to aquatic sites.
 - ❑ Do not apply dormant spray when soil water content is at field capacity and rain is predicted within 48 hours.
 - ❑ Apply when wind speed is 3-10 mph at the application site.
 - ❑ When wind is >3 mph toward aquatic sites begin spraying at side nearest aquatic site and then move upwind.
 - ❑ Shutoff spray equipment near end of rows.
 - ❑ Use larger droplet size and lower pressure and drift retardant chemicals in spray mix.
 - ❑ Spray last three rows upwind of aquatic sites using nozzles on one side only with spray directed away from aquatic site.
- **Vegetation**—as discussed in the nutrient and sediment management sections vegetation can have several beneficial impacts on pesticide management. Other specific vegetation management practices include:
 - ❑ Cover crops can adsorb pesticides and prevent them from moving off-site, also faster breakdown when adsorbed to vegetation.
 - ❑ Spray only around base of trees.
 - ❑ Leave a vegetated strip at the tail end of fields.
 - ❑ Roadways can be grassed or sod planted.
 - ❑ Filter ditches—areas filled with activated charcoal, peat or other organics that adsorb pesticides.

Rice Water Quality Management

State mandates currently require rice growers to hold herbicide-treated waters on their fields to allow dissipation or breakdown of herbicides into nontoxic products. The water-holding requirements make it necessary for farmers to control water flow more carefully. The three main water management systems that are currently used by rice growers include: conventional, recirculating, and static systems.

In the past, almost all rice farms were irrigated with conventional flow-through systems where water flows into one “check” or basin and then to the next check. Finally, the water flows out of the bottom check and into a drain. Conventional system water management problems have made it increasingly difficult for rice growers to comply with the required water-holding periods.

Closed systems, such as the recirculating and static systems, are considered to be best management practices for holding treated water because they can reduce pesticide residue mass discharge by up to 97% over conventional systems. In recirculating systems, water is pumped from the bottom check back to an uphill field, usually on the same farm. Some of these systems have been implemented at the irrigation district level, but most were built by individual farming operations. A static system independently controls inflow into each basin and limits it to the amount required to replenish applied water lost to evapotranspiration and percolation. It also eliminates the possibility of spillage of field tailwater into public drains.

Irrigation Water Management

Practices in this category are designed to optimize the use of irrigation water for crop production. This is achieved by matching the timing and uniformity of irrigation to the soil water depletion. Over irrigation can lead to surface runoff and deep percolation. Farm level practices that can reduce surface runoff include water budgeting, conversion of surface irrigation systems to pressurized systems and increasing the uniformity of application to prevent excessive deep percolation. When growers use surface irrigation, measures that reduce erosion and surface runoff include tailwater ponds and cutback irrigation. District-level practices that allow a grower to better match supply with demand include increasing delivery flexibility through adjustments to rate, duration and frequency. When nutrients and pesticides are used in irrigation systems, proper backflow prevention devices are required to prevent contamination of source water. In addition to the hardware discussion in the sediment transport section of this document, irrigation scheduling can also be an affective management practice.

Monitoring soil water depletion through field sensors, California Irrigation Management and Information System (CIMIS) or moisture by feel analysis is important for determining when to irrigate. If the soil water profile is too high when irrigating then depth of water infiltrated will be reduced resulting in more surface water runoff. If previous irrigations have sealed the soil surface then it

may be necessary to cultivate the furrows to break up the surface skin so that the irrigation water can infiltrate.

Proper depth of application is important for preventing the movement of nitrates and other mobile constituents to groundwater. The depth of application is a function of the soil type, irrigation system and existing soil water depletion.

Proper timing of irrigations reduces crop stress and susceptibility to disease and pest infestation. Improper timing of irrigations can occur either too early or too late. Soil water content and the depth of application should be monitored.

Backflow prevention device—when using irrigation water an air gap or back flow prevention device is required to prevent movement of chemical into waterways or wells.

Education and Outreach

The objective of education and outreach is to provide end users with information they can use to make decisions about which management practices to implement to prevent surface and groundwater contamination. Education must be tailored to the local conditions, crops and economics. Outreach needs to be done by individuals that understand local conditions and the affect the various management practices have on the constituents of concern. Many of the commodity groups maintain outreach information regarding current practices for pesticide and nutrient management. Labeling was discussed under the pesticide section of this document. Specific actions known to reduce the impact are:

- **Mixing location**—an asphalt or concrete mixing pad that drains to a central sump should be used. Mixing location should be at least 100 feet from all water bodies.
- **Equipment**—all equipment should be continuously checked for cracks and broken components. Spray nozzles should be adjusted for the crop and soil type for which it will be used.
- **Tank filling**—partially fill tank prior to the addition of chemical, use air gap to prevent overfilling and use backflow device on fill tube.
- **Personnel**—ensure that qualified personnel are mixing and applying chemicals. Always have personnel present during tank filling and to take corrective action when necessary.
- **Cleanup**—triple rinse all equipment, apply rinseate to field, clean all equipment at least 100 feet from water bodies.

Other Resources

Several statewide grant programs have been available to address impacts to water quality. Funding was made available for research, demonstration, monitoring and

implementation projects. Table 5-4 lists recent grants awarded from various sources for implementation projects, education, demonstration and outreach efforts and applied research.

Table 5-4. Recent Water Quality Grants by Various Funding Agencies

Applicant	Project Title
Education, Demonstration and Outreach	
Agriculture and Land Based Training Association	Agricultural NPS Reduction: Demonstration, Outreach and Education
Protected Harvest	Common Goals Towards Conservation: Creating a CA Sustainable Processing Workbook
Yolo County RCD	Yolo-Solano Ag Water Quality Management Support Program
Glenn County Dept. of Agriculture	Glenn County Surface Water Stewardship
Coalition for Urban Rural Environmental Stewardship	Promotion of Farming Best Management Practices and Calibration Technology to Mitigate Organophosphate Pesticide runoff into the Sacramento River Watershed
Agriculture Research Consulting	Implementation of BMO to Mitigate Organophosphate Pesticide Runoff
Implementation	
Sonoma Ecology Center	Plymouth Area Vineyard Erosion Control
California Avocado Commission	Implementation of On grove Reverse Osmosis to Reduce TDS and Chlorine Impairments
Contra Costa RCD	Application of Beneficial Management Practices to Reduce Runoff from Irrigated Agriculture
El Dorado County RCD	Agricultural Stewardship Project for the South Fork American River Watershed
Grasslands Water District	Adaptive, coordinated real-time management of wetland drainage
Panoche Drainage District	San Joaquin River Water Quality Improvement Project- Reuse Development Project
Patterson Irrigation District	Real-Time, Salt and Nutrient Drainage Load Reduction Strategies - Patterson & West Stan ID
Reclamation District 800	Lower Kellogg Creek Bio-Filter / Retention Pond Implementation Project
Stevinson Water District	Agricultural Drainage Control Project
Sutter County RCD	Implementation of Feather River TMDL For Orchards
Monterey County Resource Conservation District	Conversion of Agricultural Drainage Ditches into Treatment Wetlands
Western Shasta Resource Conservation District	Williams Ranch Tailwater Collection Pond
The Regents of the UC, Co-op Extension	Upper Feather River Watershed (UFRW) Irrigation Discharge Management Program
Research	
EPA Region 9	Benefits of Vegetated Agricultural Drainage Ditches (VADD) as a Best

Applicant	Project Title
	Management Practice in Yolo County, California
UC Co-op Extension	Irrigation Management Measures to Improve the Quality of Surface Runoff Water
Calif. Certified Organic Farmers Foundation	Going Organic Project
Central Coast Vineyard Team	Vineyard Ag Waiver Compliance & Comprehensive Evaluation of Cover Crops to Protect Water Quality
Coalition for Urban Rural Environmental Stewardship	West Side San Joaquin Watershed Irrigated Agricultural Water Quality
Regents of the UC	Management practices for mitigating off-site transport of soil-adsorbed pesticides
San Joaquin County RCD	Measuring the Effectiveness of Ag. Management Practices
Sustainable Cotton Project	Improving Surface Water Quality in San Joaquin River Basin Through Sustainable Cotton Production
UC Co-op Extension	Effective Management Practices to Treat and Reuse Agricultural Drainage Waters
UC Davis	Alternative Agricultural Management Strategies to Reduce Runoff and Improve Water Quality
UC Davis	Developing a Water Quality Stewardship for Alfalfa
University of California	Reducing sediment and nutrient loss from commercial vegetable fields
University of California, Davis	Pheromone Mating Disruption as an Alternative to Organophosphate Use in Walnuts: A Cost Analysis
University of Redlands	Spatial Data Infrastructure to Implement and Monitor NPS Pollution

There is a minimum expectation that managers for irrigated agriculture will implement best management practices on individual operations that will improve water quality when necessary, regardless of the direct linkage to a specific operation through water quality testing.

Managed Wetlands— Sacramento River Watershed Subbasins

Pit River

Managed Wetlands

Modoc National Wildlife Refuge

Modoc National Wildlife Refuge (NWR) is located in Modoc County just south of the city of Alturas. The refuge was authorized in 1959 by the Migratory Bird Conservation Commission and presently totals 7,020 acres. The refuge is managed for waterfowl production and migration, and is a major production area for the greater sandhill crane. Approximately 2,000 acres of wetlands are managed on the refuge. Also 2,180 acres of wet meadows are managed for sandhill cranes and Canada goose forage.

Ash Creek Department of Fish and Game Wildlife Area

The Ash Creek Wildlife Area (WA) is located 4 miles northeast of the town of Bieber and consists of 14,754 acres in the heart of Big Valley. The area contains 3,000 acres of natural wetlands and is managed for waterfowl and sandhill crane production and migration. The refuge manages 710 acres of wetlands on seasonal flow from six streams.

Private Wetlands

There are few managed private wetlands in this subbasin. Most private wetlands are maintained as flow through areas or are re-flooded agricultural fields utilized for waterfowl hunting in the fall and winter months.

Water Supplies

Modoc National Wildlife Refuge

Modoc NWR utilizes water under diversion and storage licenses from tributaries of the North Fork Pit River (Parker Creek and Stockdill Slough) and Pine Creek, as well as water rights from the South Fork Pit River. The USFWS purchased the Dorris Reservoir Unit in 1960. When at full legal capacity Dorris Reservoir covers 1,080 surface acres and stores about 11,100 acre-feet of water. The refuge has the right to use all of the storage capacity of the reservoir.

The South Fork Pit River supplies are diverted to the adjacent floodplain wetland units when flows are adequate. Diversions are usually possible year round except at lowest flow periods in July and August. In addition the refuge has water rights to divert directly from Pine Creek for irrigation and stock water on the south and east management units of the refuge. Total annual water use on the refuge is approximately 11,000 acre-feet.

Ash Creek Wildlife Area

The water supply for the Ash Creek WA is provided by seasonal flows from Ash Creek and five other streams. These flows maintain natural and managed refuge wetlands. The water supply is managed by a flow through system on an available flow basis with water returning to Ash Creek downstream of refuge wetlands.

Private Wetlands

Water supplies for private wetlands are not certain for this area. Most rely upon spring runoff and additional flows to maintain year round wetlands. Others may utilize return flows from irrigated pastures and/or wild rice units when available.

Constituents of Concern

Constituents of concern for the Pit River as identified by CWA Section 303(d) and Central Valley Water Board are nutrients, organic enrichment/low dissolved oxygen (DO), and temperature. The primary potential sources of these constituents are agriculture and grazing.

Current Management Practices

All management practices utilized at the Modoc NWR and Ash Creek WA are intended to maintain and enhance wetland habitat for the benefit of the fish and wildlife resources the occur on each area. However, no management practices are specifically directed to address water quality concerns of discharged water. These practices include:

- Manipulating water levels in wetland units to encourage desirable wetland vegetation that will provide food and cover for waterfowl and other migratory water birds.
- Wet meadows at the Modoc NWR are irrigated from April through July annually, and then allowed to dry to encourage maximum grass production.
- When mature in late August, the wet meadow grasses are mowed and baled by cooperators who remove the hay from the fields. The grasses are then ready to provide desirable habitat and food for Canada geese and sandhill cranes.

- Water diversion and distribution facilities are maintained to assure proper water flows and depths.

Available Water Quality Information

There is no direct water quality information for the wetlands supplies or return flows that is currently known to be available. A water quality survey for baseline information on alkalinity, CO₂, hardness, DO, pH, and temperature was conducted at eight locations on Modoc NWR in 1996. However the results of this survey are not available from the refuge and will require further research if needed.

The Ash Creek WA does not conduct water quality related activities. Management activities on both Modoc NWR and Ash Creek WA, as stated above, are intended to manage wetland habitat for the benefits of utilizing wildlife populations; any improvement to water quality would be considered an ancillary benefit.

Colusa Subbasin

Managed Wetlands

Sacramento National Wildlife Refuge

Sacramento NWR is located in Glenn and Colusa Counties six miles south of the city of Willows. The refuge was authorized in 1937 and presently totals 10,783 acres. The refuge is managed as a waterfowl wintering area. Seasonal, semi-permanent, and permanent wetlands are managed for waterfowl and other wetlands-dependant wildlife that utilize the refuge.

Delavan National Wildlife Refuge

Delavan NWR was authorized in 1962 and is located east of the town of Maxwell in Colusa County. The refuge totals 5,797 acres of uplands, semi-permanent wetlands, and seasonal wetlands. The refuge wetlands are managed for migrating and wintering waterfowl and other wetlands-dependant birds.

Colusa National Wildlife Refuge

Colusa NWR was authorized in 1944 and currently totals 4,956 acres just west of the city of Colusa in Colusa County. The refuge manages seasonal and semi-permanent wetlands for migrating and wintering waterfowl, as well as several listed threatened and endangered species such as the giant garter snake.

Sacramento River National Wildlife Refuge

Sacramento NWR was authorized in 1986 and consists of several units along 77 miles of the Sacramento River between the Cities of Tehama to Colusa. The refuge currently consists of 10,000 acres of riparian and floodplain wetlands, as well as walnut, prune, and almond orchards. The orchards are managed by the previous landowner or co-operator and will be until the trees are removed and replaced with native riparian vegetation. The Llano Seco unit contains the only managed wetlands of the refuge. These seasonal wetlands are managed for migrating and wintering waterfowl and shorebirds.

Private Wetlands

The major private wetlands areas within the Colusa Subbasin are located in the Willow Creek and Lurline areas in Colusa County. These areas consist of seasonal wetlands flooded from October through February for wintering waterfowl and recreational hunting. The Willow Creek area is located east of the Sacramento NWR and the Lurline area is located south of Delavan NWR. The USFWS holds conservation easements on 6,000 acres of these private wetlands. The Department of Fish and Game also has an active conservation easement program in this basin. They have acquired easements on 358 acres to date.

Water Supplies

National Wildlife Refuges

The Sacramento, Delevan, and Colusa NWRs are authorized to receive Central Valley Project (CVP) water supplies per the 1992 Central Valley Project Improvement Act (CVPIA). These water supplies are used to manage refuge wetland units and enhance riparian habitat.

Sacramento River Refuge

The Llano Seco unit contains the only managed wetlands in the Sacramento NWR. Water supplies for this area are provided by the Parrot Ranch under its Butte Creek water right.

Constituents of Concern

Constituents of concern for the Colusa Subbasin as identified by the Central Valley Water Board for the Colusa Basin Drain include the following:

- Azinphos-methyl
- Carbofuran/ Furadan

- Diazinon
- Group A pesticides
- Malathion
- Methyl Parathion
- Molinate/Odram
- Unknown toxicity

The primary source of these constituents is agriculture and/or irrigation tailwater.

Current Management Practices

National Wildlife Refuges

Management practices utilized on each of the NWRs in the Colusa Basin are intended to flood and/or maintain several types of wetland habitats and more recently irrigation of riparian forest restorations at the Sacramento River NWR. None of the management practices are undertaken to specifically address potential water quality concerns. Management practices that may provide ancillary benefits to water quality include the following:

- Irrigation of seasonal wetland units for waterfowl food production through application of water to encourage plant growth in a unit and allowing water to dissipate through evapotranspiration. This practice is utilized primarily for the production of swamp timothy.
- Manipulation of water levels in wetland units to maximize habitat benefits and encourage desirable vegetation that will provide cover for waterfowl and other migratory water birds. This management practice is utilized on seasonal semi-permanent and permanent wetlands.
- Control of undesirable vegetation and densities is generally conducted through mechanical and controlled fire practices.
- Use of herbicides/pesticides is limited to upland areas and all chemical use requires completion and approval of Pesticide Use Proposals (PUP) in accordance with USFWS and Department of Interior requirements. In the past two years (2004–2005), 99 acres were treated within the refuge complex. When use of aquatic herbicides is deemed necessary, it is strictly controlled by an extensive list of procedures that ensure application is completed only when it is certain that no treated water will leave the confines of the refuge.
- Mosquito abatement is conducted by the appropriate abatement district and is also subject to PUP application and approvals.
- Flood-up for fall and winter waterfowl use begins August 1st and continues on a stage basis until full habitat availability is reached usually October 1st.

Once all desired habitat is flooded, it is maintained on a flow through basis until draw down is initiated beginning in early March.

- Irrigation for food production is initiated in late April. Swamp timothy units receive a single irrigation each spring, except in dry years. Watergrass and mixed marsh units generally receive two to three irrigations, after which plants are allowed to mature, and then flooded in accordance with a schedule developed each year.

Available Water Quality Information

Water quality information for the NWRs in the Colusa Subbasin is limited. Most of the information is contained in investigations and/or conducted research associated with waterfowl disease and mosquito abatement activities. The USGS conducted an investigation, *Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Sacramento National Wildlife Refuge Complex, California*, Investigation report 92-4036.

In addition, from 1986–1989, the USFWS National Wildlife Health Lab and Northern Prairie Research Center conducted research on avian botulism in waterfowl on the Complex. This research involved several environmental quality aspects of the disease cycle and water quality, both supply and wetland water were included. A number of reports were generated and are available in refuge files.

Recently, the refuge, in cooperation with mosquito abatement districts, has conducted abatement activities research that has targeted impacts on non-target organisms (both single application and cumulative affects) and has involved a number of quality parameter tests. No formal reports have been published.

A wastewater treatment plant is operated at the Sacramento NWR headquarters. The facility is a class 3B and subject to State Water Board regulations and requirements related to water quality, containment, etc. The system is designed to be self-contained; no water is released from the plant into any stream, wetland, or upland. Over the past five years, major improvements to the overall system have been implemented, including a one acre second evaporation pond.

No water quality information is known to exist specifically addressing the privately owned and managed wetlands in the Willow Creek-Lurline areas.

Butte-Yuba-Sutter Subbasin

Managed Wetlands

Sutter National Wildlife Refuge

The Sutter NWR was authorized in 1944 and totals 2,591 acres. The refuge is located in the Sutter Flood Bypass south of Highway 20 and west of Yuba City. The refuge was established to assist in the alleviation of crop damage caused by wintering waterfowl. The refuge is presently managed for this purpose and to provide habitat for wintering waterfowl and other wetland-dependant migratory birds.

Butte Sink National Wildlife Refuge

Butte Sink NWR was authorized in 1976 and consists of 10,254 acres of conservation easements on privately owned wetlands and 733 acres of fee title wetlands. The fee title area is managed as seasonal wetlands for wintering waterfowl and migratory shore birds.

Gray Lodge Wildlife Area

The Gray Lodge WA, managed by the California Department of Fish and Game (DFG), totals 9,200 acres of which 6,300 acres are managed wetlands. The refuge is one of the first wildlife areas established in the Central Valley. It is managed for migratory waterfowl as a wintering area and public hunting and fishing in accordance with State regulations.

Upper Butte Basin Wildlife Area

The Upper Butte Basin WA is located west of Gridley, CA adjacent to Butte Creek. The area totals 9,376 acres of which 6,800 acres are managed wetlands. The WA is composed of three management units, Howard Slough, Little Dry Creek, and Llano Seco. Management to provide waterfowl and upland game habitat and public hunting opportunities are the primary objectives of the WA.

Spenceville Wildlife Area

The Spenceville WA is located in Nevada and Yuba Counties, 15 miles east of Marysville, CA. The WA totals 11,448 acres of which 81 acres are managed wetlands. The remainder of the area contains foothill oak and grassland habitat. The wetlands are managed to provide water for upland game and habitat for waterfowl.

Private Wetlands (Butte Sink)

Discussion of the Butte Sink NWR occurs above. In addition to the USFWS conservation easements, an additional 8,000 acres of privately owned wetlands are found adjacent to and within the Butte Sink. The DFG also has an active easement program in this basin, currently protecting 3,416 acres of the private wetlands. These wetlands are primarily managed as waterfowl hunting clubs. Water in the private Butte Sink wetlands is managed on a flow through basis to maintain water quality and to minimize effects on salmonids that migrate up and down Butte Creek.

Water Supplies

Sutter National Wildlife Refuge

The Sutter NWR is authorized to receive waters supplies from the CVP in accordance with the CVPIA. However, the refuge is awaiting a final conveyance agreement and is currently utilizing the same water supplies available prior to enactment of CVPIA.

The water supply for the 500 acres located outside the Flood Bypass is provided by the Sutter Extension Water District and by groundwater. The Sutter Extension supplies are a firm reliable Feather River supply that is expected to continue. Groundwater is utilized to supplement needs, primarily in the late winter months.

The water supply for the wetlands inside the Flood Bypass consists of diversions from the East Borrow Channel under USFWS water rights and winter flood flows. Sufficient water flows are diverted to the East Borrow Channel by water managers to meet the needs of diverters from that channel, including the refuge.

Butte Sink National Wildlife Refuge

Water supplies for the 733 acres of fee title lands within Butte Sink NWR are diverted from Butte Creek, the primary water course through the Sink. This water is diverted upstream of the NWR and flows through adjacent private hunting clubs before reaching the NWR. These lands and other wetlands within the Butte Sink are entitled to water supplies in the fall and winter in accordance with a 1925 agreement with agricultural and other users upstream of the managed wetlands. In addition, the Butte Sink area is frequently flooded during winter when high water flows in the Sacramento River and Butte Creek are diverted into the area at the Colusa Weir. These flows continue through the Sink to the Sutter Flood Bypass before co-mingling with Feather River flows and back to the Sacramento River.

Gray Lodge Wildlife Area

Gray Lodge WA is authorized to receive water supplies from the CVP in accordance with CVPIA. Reclamation recently entered into an agreement with the Biggs West Gridley Water District (BWGWD) to convey CVPIA supplies to the refuge. The agreement allows for a 6–7 year facility upgrade period before full CVPIA supplies can be delivered on a reliable basis. Therefore the WA continues to utilize water rights and BWGWD entitlements for primary and secondary lands supplemented by groundwater from refuge wells.

Upper Butte Basin Wildlife Area

The Upper Butte Basin WA water supplies include the Sacramento River and Butte Creek water purchased from The Parrot Ranch, Feather River water purchased from Western Canal Water District and Richvale Irrigation District and groundwater from WA wells.

Spenceville Wildlife Area

Managed wetlands on the Spenceville WA are provided with water purchased from Nevada Irrigation District.

Private Wetlands (Butte Sink)

The water supply for the private wetlands in the Butte Sink is primarily derived from the 1925 Agreement mentioned above in the NWR discussion. This water is diverted from Butte Creek. In addition, groundwater is utilized to meet wetland needs.

Private wetlands adjacent to the Butte Sink rely upon agricultural and other wetland return flows to meet water supply needs.

Constituents of Concern

The major constituent of concern for Butte Creek and the Sutter Bypass, as identified in the CWA Section 303(d) 2002 list, is diazinon. The potential source for this constituent is from crop-related runoff and agriculture.

Current Management Practices

Management practices utilized on the managed wetlands in the Butte-Yuba-Sutter Subbasin are intended to flood and/or maintain several types of wetland habitats and more recently irrigation of riparian restorations. Management

practices that may provide ancillary benefits to water quality include the following:

- Spring irrigation of seasonal wetland units for waterfowl food production through application of water to encourage plant growth in a unit and allowing water to dissipate through evapotranspiration. This practice is utilized primarily for the production of swamp timothy.
- Fall and winter manipulation of water levels in wetland units to maximize habitat benefits and encourage desirable vegetation that will provide cover for waterfowl and other migratory water birds.
- Control of undesirable vegetation and densities is conducted through mechanical and controlled fire practices.
- Use of herbicides/pesticides is limited to upland areas. All chemical use on USFWS NWRs requires completion and approval of PUP in accordance with USFWS and Department of Interior requirements.
- Mosquito abatement is conducted by the appropriate abatement districts. The districts conducting abatement activities on NWRs are also subject to PUP application and approvals.
- Flood-up for fall and winter waterfowl use begins August 1st and continues on a staged basis until full habitat availability is reached, usually October 1st. Once all desired habitat is flooded, it is maintained on a flow through basis until draw down is initiated beginning in late February and early March.
- Irrigation for food production is initiated in late April. Swamp timothy units receive one irrigation except in dry years. Watergrass and mixed marsh units generally receive two to three irrigations after which, plants are allowed to mature, and then flooded in accordance with a pre-developed schedule.

Available Water Quality Information

Available Information for the Sutter and Butte Sink NWRs is found in the USGS Investigation Report No. 92-4036 as discussed for the Colusa Subbasin above. Also, the reports developed from the avian disease research discussed for the Colusa Basin may contain water quality information on the Sutter NWR.

Groundwater currently provides a portion of wetland water supplies at the Gray Lodge WA. DFG measures groundwater levels for both active and inactive wells on a monthly basis and provides the information to Reclamation. Reclamation collects monthly electrical conductivity (EC), pH and DO samples from each well used to provide surface supply. In addition, Reclamation tests groundwater for specific conductance, arsenic, chromium, iron, and manganese; and surface water for DO, specific conductance, chromium, hardness, and pH prior to pumping groundwater and one month after pumping stops.

Reclamation is proposing to expand surface water monitoring at major inflow and outflow points for temperature and EC.

Waste Discharge Requirements (Order No. 5-01-088) have been issued to DFG for the closed Spenceville Mine at the Spenceville WA. Monitoring is required as part of the Monitoring and Reporting Program for the unsaturated zone, reclaimed pit, and groundwater specific conductance, pH, total dissolved solids (TDS), total suspended solids (TSS), turbidity, alkalinity, hardness, manganese, sodium, potassium, calcium, magnesium, chloride, sulfate, and 11 metals.

DFG purchases approximately 25 miners inches of water per year from Nevada Irrigation District to augment flow in Wellman Creek during the April–October period. This added flow improves water quality below the Farm Ditch in the “1000 Acre” parcel.

At the Upper Butte Basin WA, Reclamation recently initiated monitoring of groundwater quality at two wells. Specific information on the type of monitoring is lacking at this time.

Solano-Yolo Subbasin

Managed Wetlands

Yolo Bypass Wildlife Area

The Yolo Basin WA is located in the Yolo Flood Bypass east of the City of Davis, California. The WA manages over 15,830 acres for fish, wildlife, and recreational benefits, including 4,066 acres of managed wetlands.

Private Wetlands (Conaway Ranch etc.)

Private wetlands in the Solano-Yolo Subbasin are primarily located within the Yolo Flood Bypass. The total number of acres of private wetlands is estimated at over 17,000. The USFWS has perpetual conservation easement on 4,531 acres of private wetlands. DFG also has an active conservation easement program in the Yolo Bypass with a total of 1,763 acres under easement. In addition, the NRCS has a wetland easement and restoration program under the Wetland Reserve Program that has restored and protected over 2,000 acres of former agricultural lands within the Bypass. Several tracts owned and managed by other governmental agencies or non-profit organizations, such as Liberty Island, are areas that have reverted to wetlands due to levee breaches and are subject to tidal fluctuations.

Stone Lakes National Wildlife Refuge

The Stone Lakes NWR was established in 1994 and currently manages 4,065 acres within the approved 18,000-acre boundary. A total of 1,400 acres of wetlands are currently managed, with additional wetland restoration planned for

the near future. The NWR is in an active acquisition program aimed at meeting the land and habitat protection goals as approved in 1992.

Cosumnes River Preserve

The Cosumnes River Preserve, established in 1987, is a unique cooperative effort between Local, State, and Federal agencies and private conservation organizations that has acquired over 40,000 acres of habitat, through fee and easement purchases, within the Cosumnes River watershed. The primary goal of the Preserve is the protection and restoration of the floodplain and associated riparian habitats along the only remaining free-flowing river within the Central Valley. The Preserve has created over 1,500 acres of new wetlands, of which 1,080 are managed.

Water Supplies

Yolo Bypass Wildlife Area

The water supply for the Yolo Basin includes water diverted from Putah Creek and the Yolo Bypass toe drain.

Private Wetlands

Water supplies for the private wetlands within the Yolo Basin Flood Bypass are diverted from the toe drain, Sacramento River, and through pumped groundwater.

Stone Lakes National Wildlife Refuge

Water sources for the Stone Lakes NWR include Morrison Creek, agricultural drainage, North and South Stone Lakes, and groundwater. The refuge also has many small waterways that originate in urban and agricultural areas and empty into refuge wetlands.

Cosumnes River Preserve

Water supplies for the Cosumnes River are dependent upon tidal flows. The Preserve has a secondary right to pump tidal water for management of the various habitat types on the area including wetlands.

Constituents of Concern

The constituents of concern for the Solano-Yolo Subbasin are those identified for the Delta Waterways in the CWA Section 303(d) list as identified by the RWQCB and include the following:

- Chlorpyrifos, DDT, diazinon, Group A pesticides, mercury, and unknown toxicity. The potential sources for these constituents are agriculture, urban runoff/storm sewers, and resource extractions (mining).

Current Management Practices

The Yolo Bypass WA does not undertake any wetland management practices that are designed to specifically address water quality concerns for return flows. Water management practices utilized for WA wetlands are similar to those discussed for the other subbasin wetlands discussed above. These management practices may have ancillary benefits to water quality. As with the practices discussed above, habitat maintenance and enhancement are the primary focus of water management on the area.

Water management practices at Stone Lakes NWR are limited by available water supplies. Wetland units are flooded in the early fall and maintained through the winter period. Some wetland units are influenced by tidal fluctuations in North and South Stone Lakes and Snodgrass Slough.

The Cosumnes River Preserve water management practices are dependant on available river flows and are utilized in a very similar manner as other managed wetlands in the Sacramento Valley. The primary focus of water management practices is the maintenance of wetlands for the fall and winter period and restoration of riparian habitat.

Private wetlands are managed as waterfowl hunting areas and are flooded during the fall and winter months. The area routinely floods each year, inundating wetlands until flows recede in the spring.

Available Water Quality Information

Yolo Basin Wildlife Area

The City of Woodland CALFED Watershed Grant Agreement 4600001691 monitored bacteria, boron, metals, organic carbon, pesticides/herbicides, salinity, and total suspended solids throughout the Yolo Bypass, including one site on the Yolo Basin WA. The monitoring occurred over a one-year period and the agreement is proposing to produce a water quality management plan to address degradation of surface water.

Sacramento River Watershed Program Mercury Methylation Study, Proposition 50 Grant, from the State Water Board proposes that water quality monitoring will provide an indication of the extent to which mercury transformation processes in wetlands may affect downstream water quality with regard to methylmercury. Water quality sampling will include selected inflow and outflow sites from the Yolo Basin WA wetlands. Water quality analyses will include filtered and unfiltered total mercury and methylmercury, total suspended solids, major cations, anions, trace metals, nutrients, and dissolved particulate carbon.

Stone Lakes National Wildlife Refuge

Various studies by the Sacramento Regional Wastewater Treatment Plant and USFWS have been completed to date on the refuge and in the surrounding area.

The contaminant assessment was conducted on Refuge waters by USFWS in 1997. The assessment provided known sources of contamination and a survey of potential contaminant sources, pathways, and problems.

Additional USFWS studies conducted in Morrison Creek during 1999 and 2000 found that levels of diazinon were sufficient to kill fish and affect other wildlife after a rainfall greater than one inch. The potential source of these pesticides is storm water runoff drainage, flushed through urban stormwater drains.

The Sacramento Regional Wastewater Treatment Plant conducts ongoing quarterly water sampling for certain trace elements from several sites along Morrison Creek, Laguna Creek, Meadowlark Lake, and Black Crown Lake. The Army Corp of Engineers sampled water from the Morrison Creek Watershed from 1982 to 1984. Concentrations of cadmium, copper, and lead exceeded the EPA acute toxicity criterion for aquatic life in all samples. The DFG and State Water Board collected and analyzed large mouth bass from Meadowlark Lake from 1985 to 1987 and analyzed for heavy metals and organochlorine pesticides. Elevated levels of mercury, copper, chlordane, dacthal, total DDT and total PCBs were detected.

Cosumnes River Preserve

University of California, Davis is conducting a remote monitoring program on the Cosumnes River. The overall goal of the monitoring program is to ascertain hydrogeomorphic and ecologic responses to the floodplain restoration program using levee breaches to reinstate natural processes on former agricultural lands for the purpose of recreating functioning floodplains that also reduce financial losses from floods. The supporting objectives include assess both methodological concerns regarding how to address geomorphic problems with multi-temporal scaling issues, as well as fundamental processes of water, sediment, and contaminant transport on floodplains.

In addition the USGS is monitoring mercury at one sample site on the Preserve as part of a nationwide program. A monitoring site has been established at Twin Cities Road to sample River flows as part of the subbasin compliance with the current Irrigated Lands Waiver Program.

Managed Wetlands—San Joaquin River Subbasins

West Side San Joaquin Valley

Managed Wetlands

San Luis National Wildlife Refuge Complex

The San Luis NWR Complex is composed of the San Luis NWR (San Luis, Kesterson, West and East Gallo units), San Joaquin River NWR and Merced NWR (Merced and Arena Plains units). Although the Merced NWR is located east of the San Joaquin River it is included here to maintain continuity of discussion of the overall NWR complex. The refuge complex totals approximately 43,000 acres. These refuges manage over 150 separate wetland units totaling 9,000 acres. The balance of the lands consists of native uplands, floodplains, vernal pools, riparian forest, and 1,974 acres of cropland.

Los Banos Wildlife Area

Los Banos WA was established in 1929 as the first of a series of waterfowl refuges established throughout the state for wintering waterfowl. The WA currently totals 6,217 acres of wetland habitat composed of lakes, sloughs and managed marsh. The refuge is located 4 miles northeast of the City of Los Banos in Merced County.

Volta Wildlife Area

Volta WA is located $\frac{3}{4}$ of a mile north of the town of Volta in Merced County. The area totals 2,891 acres of managed marsh and valley alkali shrub. The area is managed as a wintering area for waterfowl and shorebirds.

North Grasslands Wildlife Area

The North Grasslands WA is comprised of the China Island Unit, the Salt Slough Unit, and the Gadwall Unit. The three units are located within close proximity to the Cities of Los Banos and Gustine. The WA totals 7,069 acres of wetlands, riparian habitat and uplands managed for wintering waterfowl, Swainson's hawk, and sandhill cranes.

Grassland Resource Conservation District

The Grassland RCD is comprised of the Grassland Water District, San Luis NWR, and Los Banos, Volta and North Grassland WA's. The private lands within the Grassland Water District and RCD are hunting clubs totaling approximately 70,000 acres of which about 39,000 are managed wetlands.

The USFWS has an active conservation easement program in the RCD and has acquired easement on over 50,000 acres to date. DFG also has an active easement program within the San Joaquin River Subbasin and has acquired 994 acres of easements to date.

Water Supplies

The water supplies for the San Luis and Merced NWRs, Los Banos and Volta WA's, and the Grassland RCD are authorized by the CVPIA and provided by Reclamation from the CVP. However, the Merced NWR receives water supplies from the Merced Irrigation District as mitigation for the New Exchequer Dam and also utilizes groundwater supplies.

Constituents of Concern

Constituents of concern for the Westside drainages as identified by CWA Section 303(d) and Central Valley Water Board are chlorypyrifos, diazinon, EC, selenium, boron, Azimphos-methyl, DDE, Group A pesticides, mercury, sediment, and unknown toxicity. Table 5-5 presents a list of impaired water bodies near the West Side San Joaquin Valley.

Table 5-5. CWA 303d List of Impaired Water Bodies near the West Side San Joaquin Valley

Waterbody	Constituent	Potential Sources
Del Puerto Creek	Chlorpyrifos, Diazinon	Agriculture
Grassland Marshes	EC	Agriculture
Ingram Hospital Creek	Chlorpyrifos, Diazinon	Ag return flows
Mendota Pool	Selenium	Agriculture, agricultural return flows, groundwater withdrawal, other
Mud Slough	EC, Selenium, Boron, Unknown toxicity, Pesticides	Agriculture
Newman Wasteway	Chlorpyrifos, Diazinon	Agriculture
Orestimba Creek	Unknown toxicity, Chlorpyrifos, Diazinon, Azinphos-methyl, DDE	Agriculture
Panoche Creek	Selenium, Mercury, Sediment	Agriculture, grazing, roads, mining
Salt Slough	EC, Boron, Unknown toxicity, Chlorpyrifos, Diazinon	Agriculture
San Joaquin River		
Bear Creek to Mud Slough	EC, Boron, Unknown toxicity, Chlorpyrifos, Diazinon, Group A Pesticides, DDT, Mercury	Agriculture, mining
Mendota Pool to Bear Creek	EC, Boron, Unknown toxicity, Chlorpyrifos, Diazinon, Group A Pesticides, DDT	Agriculture
Merced River to South Delta Boundary	EC, Boron, Unknown toxicity, Chlorpyrifos, Diazinon, Group A Pesticides, DDT, Mercury	Agriculture, mining
Mud Slough to Merced River	EC, Selenium, Boron, Unknown toxicity, Chlorpyrifos, Diazinon, Group A Pesticides, DDT, Mercury	Agriculture, mining

Current Management Practices

Existing Water Quality Monitoring

San Luis National Wildlife Refuge

Hourly flow and salinity data throughout 2002 and 2003. Only one inlet and three outlets were instrumented in the San Luis Unit of the Refuge Complex. Of these adequate data was obtained at only two of the outlets.

Grassland Water District

A more comprehensive monitoring network has been operational in the Grassland Water District for the past 4 years. The monitoring network comprises both inlet and outlet sensors measuring flows and salinity, data is transmitted hourly to a satellite and made available to water managers on a district website.

Participation in the SJV Westside Coalition

The Grasslands wetland entities have chosen to become part of the San Joaquin Valley Westside Coalition in order to comply with monitoring guidelines developed for the Agricultural Waiver Program. A watershed conditions document that describes the unique characteristics of the wetlands and a monitoring program plan document that justifies the selection and monitoring frequency of the sites chosen for the program were filed by wetland signatories to the coalition.

Water Management Plans (5 year and yearly updates)

Focus on methods to improve water use efficiency and water quality on refuge water management plans should be revised as more data becomes available to characterize current conditions on the various wetland areas that make up the Grassland Ecological area. The water management plan updates should strive to document what constitutes a best management practice relevant to each major wetland function and allow these practices to be refined, together with quantitative measures of water use, irrigation timing and drainage management. Each updated water management plan should also include updates on quantitative measures of habitat quality to provide a baseline against which improved management practices and the result of their application can be compared.

Groundwater Wells

Groundwater wells were installed in the refuges as a hedge against water shortages. Wells yielding water of acceptable quality (typically below 1500 parts per million [ppm]) are used conjunctively in refuges such as the San Luis NWR to supplement existing water supply. Wells in the State managed wetlands are less frequently used owing to the added cost of groundwater pumping. In the Grassland Water District there are no District owned production wells. Domestic wells exist within the Water District that service local duck clubs.

Grasslands Drainage Pilot Study

The State Water Resources Control Board has provided funding for a pilot implementation study of real-time water quality management in the Grasslands Ecological area. The study will comprise three paired sites in the Grassland Water District and State Wildlife Management areas. These paired sites include a control site that will be managed using traditional techniques for a period of three years and a treatment site that will be managed traditionally in year 1 and practice delayed wetland drawdown (between April 15 and May 15) in years 2 and 3. Inlets and outlets of each pair of sites will be instrumented and the telemetric data sent to the water master's office. Water monitoring will occur within each wetland to develop relationships between ambient wetland salinity and outlet salinity. Habitat assessment methodologies will be refined and implemented during each year of the study to provide a quantitative measure of the impacts of real-time water quality management implementation.

Available Water Quality Information

- Recent Studies/Monitoring of Water Quality in the Area West of the San Joaquin River:
 - ❑ USFWS studies of selenium contaminant levels in migratory birds (1989 and 1994);
 - ❑ Operational USFWS Selenium Monitoring of Mud Slough and Salt Slough (1989–1995);
 - ❑ “Selenium in the Ecosystem of the Grassland Area of the San Joaquin Valley: Has the Problem Been Fixed?” (2004);
 - ❑ “Salinity, Boron, and Nutrient Monitoring of Wetland Source Waters and Discharges at the San Luis National Wildlife Refuge Complex” (2002);
 - ❑ “Evaluation of the Effects of Management of the San Luis National Wildlife Refuge Complex Wetlands on the Dissolved Oxygen Problem in the San Joaquin River Deep Water Ship Channel” (2004);
 - ❑ Grassland Bypass Project (1996–present)

The Grassland Bypass Project is an innovative program that was designed to improve water quality in the channels used to deliver water to wetland areas. Prior to the Project, subsurface drainage water was conveyed through those channels in route to the San Joaquin River and limited their availability to deliver high-quality habitat supplies. The Project, initiated in 1996, consolidates subsurface drainage flows on a regional basis and utilizes;
 - ❑ Westside Drainage Coalition (2003–present)

Since 1982, the Central Valley Water Board has exempted agricultural operations and wetland discharges from regulation as waste dischargers;
 - ❑ DFG.

Los Banos Wildlife Area

EC measurements have been taken by DFG staff at eight major intake locations and two major drainage locations along Mud Slough periodically between January 2001 and November 2004.

Beginning in March 2005 monitoring resumed on a bi-weekly basis. As part of the Conditional Waiver, several sites are monitored near the Los Banos Wildlife Area. Salt Slough at Sand Dam is monitored by the Westside Coalition sampling for general physical characteristics, water column toxicity, sediment toxicity, drinking water constituents, and pesticides. Boundary Drain is monitored by the San Luis Canal Company upstream from the wildlife area boundary. This site is a real-time monitoring station collecting data on EC and stage. The USFWS maintains a real-time monitoring station on Salt Slough at Wolfsen Road which collects continuous data on temperature, flow and EC.

Volta Wildlife Area

In March 2005, DFG staff began measuring EC at two major intake locations, a major drainage into the Volta Wasteway, and the two major drainage locations at the wildlife area boundary. A real-time monitoring station along the Volta Wasteway has been maintained by the Grassland Water District (GWD) since 2002 and continues to be monitored as part of the Conditional Waiver. GWD also conducts monthly grab sampling at this location for boron and selenium.

North Grasslands Wildlife Area—Salt Slough Unit

EC measurements have been taken by DFG staff at seven major drainage locations periodically since 2001. As part of the Conditional Waiver, several sites are monitored near the Salt Slough Unit. The USFWS maintains four sites nearby monitoring general physical parameters, organic carbon, and several other constituents.

North Grasslands Wildlife Area—China Island Unit

Currently there is only one monitoring location maintained by the Westside Coalition as part of the Conditional Waiver near China Island. This site is located in the Newman Wasteway; however the wildlife area does not receive or discharge water into the Wasteway.

U.S. Fish and Wildlife Service—San Luis National Wildlife Refuge

Hourly flow and salinity data throughout 2002 and 2003. Only one inlet and three outlets were instrumented in the San Luis Unit of the Refuge Complex. Similar monitoring systems will need to be installed at the inlet and outlets of the other management Units of the San Luis NWR complex as well as in the State Wildlife Area Complex. Adequate resources need to be devoted to station maintenance in order to ensure data quality.

Grassland Water District

A more comprehensive monitoring network has been operational in the GWD for the past 4 years. The monitoring network comprises both inlet and outlet sensors measuring flow and salinity - data are transmitted hourly to satellite and made available to water managers on a district website.

GWD also has the following information on file:

- Grassland Water Task Force—Water Quality Analysis/Monitoring Reports 1985-1995. Required by the RWQCB program Nos. SJR001-SJR016.
- “Water Quality Impact of Wetlands on San Joaquin River, California”. L. Grober, J. Karkoski, T. Poole; 1994.
- Grassland Water District Drainage Operation Plans; 1989–c.1994; Required by RWQCB.

- Inland Surface Water Plans; 1992–c.1994; Required by RWQCB.
- “Real Time Water Quality Management in the Grassland Water District”, Nigel Quinn, et al., December 2004 (covers the period from 2001–2004).
- Grassland Bypass Project; Monthly water quality monitoring and reporting 1996–current. Data compiled by San Francisco Estuary Institute.

East Side San Joaquin Valley

Managed Wetlands

Merced National Wildlife Refuge

Merced NWR was authorized under the Lea Act in 1944 and currently totals 8,358 acres. The Merced Unit of the refuge manages 1,550 acres of seasonal wetlands, 88 acres of semi-permanent wetlands and 41 acres of permanent wetlands. In addition the unit manages 40 acres of irrigated pasture and 453 acres of cropland.

The Arena Plains Unit totals 2,460 acres which includes 222 acres on non-irrigated seasonal wetlands and 275 acres of semi-permanent wetlands.

Private Wetlands

Private wetlands east of the San Joaquin River are found on several private hunting clubs and large ranches south of Highway 140, north of Sandy Mush Road, and west of Highway 59. The USFWS has conservation easements on approximately 12,000 acres, and recently acquired 2,000 acres that will be managed by the Merced NWR as the Sno-bird unit.

Water Supplies

The Merced NWR unit is authorized water supplies in accordance with CVPIA. However, there are no facilities for delivery of CVP water. Therefore, the refuge supplies are provided by the Merced Irrigation District (MID), water rights on Duck and Deadman Sloughs, and groundwater. The MID water is available only during the irrigation season (April–October). Fall and winter supplies rely upon groundwater and water right diversions to maintain flooded wetlands.

The Arena Plains Unit water supplies are diverted under water right permits from the Atwater Drain and Bear Creek.

Private wetland water supplies are provided by groundwater, various water rights held by the landowners, and purchased water from neighboring water districts.

Constituents of Concern

Constituents of concern as identified under CWA Section 303(d) for Bear Creek and the San Joaquin River from Bear Creek to Mud Slough are listed as follows:

- Boron, Chlorophreros, DDT, Diazinon, EC, Group A pesticides, mercury and unknown toxicity.

Potential sources for these constituents are agriculture, resource extraction, and unknown.

Current Management Practices

Wetland management practices for habitat purposes, for the east side of the San Joaquin River, are essentially the same as those practiced for managed wetlands in other basins of the Central Valley. However, there are no on going management practices for managed wetlands east of the River that are focused on water quality of discharged water. At this time all the managed wetland studies and monitoring in the San Joaquin Valley are focused on the west side of the San Joaquin River as discussed above.

Available Water Quality Information

There is no information that is specific to the Merced NWR and private wetlands east of the San Joaquin River. Some of the studies discussed for the San Luis NWR may have data relative to Merced NWR.

Managed Wetlands—Tulare Lake Subbasin

Managed Wetlands

Kern-Pixley National Wildlife Refuge Complex

The Kern NWR was established in 1960 and consists of 10,618 acres of managed wetlands, riparian, and upland habitat. A total of 6,185 acres are managed as seasonal wetlands.

The Pixley NWR was established in 1959 and consists of 6,192 acres. A total of 4,392 acres is set aside as endangered species habitat. Currently, approximately 400 acres of seasonal wetlands are managed on the refuge. The remaining 1,400 acres are managed as non-irrigated uplands and dry wetlands.

Mendota Wildlife Area

The Mendota WA, located in Fresno County, consists of 11,800 acres of flood plain and managed wetlands habitat. The area is managed as a wintering area for migratory birds and public hunting.

Private Wetlands

Private wetlands in the Tulare Lake Basin currently consist of approximately 3,000 acres of private hunting clubs primarily located north and east of the Kern NWR. In addition, the NRCS has restored approximately 2,000 acres of former agricultural lands under the Wetlands Reserve Program. These wetlands are protected by conservation easements held by the U.S. Department of Agriculture.

Water Supplies

Water supplies for the Kern NWR are authorized under the CVPIA and conveyed to the refuge by the Buena Vista Water Storage District.

Water supplies for Pixley NWR are also authorized under the CVPIA and pending completion of a conveyance agreement and construction of facilities, the refuge is utilizing groundwater for the management of wetland units.

Water supplies for the Mendota WA are authorized per CVPIA and are delivered by the Bureau of Reclamation through the Mendota Pool to Fresno Slough where the water is then diverted onto the WA.

Water supplies for the private wetlands are almost entirely dependant upon groundwater. During above normal and wet hydrologic years, surface supplies may be available from local water storage districts (WSDs) such as Semi-tropic WSD.

Constituents of Concern

No CWA Section 303(d) constituents have been identified for the Tulare Basin waters adjacent to the Kern and Pixley NWRs or private wetlands. Selenium is a recognized constituent of concern at the Mendota WA along with TDS and EC.

Current Management Practices

When Kern NWR has sufficient or excess water and permission from downstream landowners, the refuge utilizes a flow through management practice to reduce the level of salts in impounded water. These flows are then released and utilized downstream on agricultural lands.

Inflow water is monitored to ensure it is not excessively high in salts and other organic or inorganic compounds. This is to assure that water utilized on the refuge is the highest quality possible.

With the increase in reliable water supplies through CVPIA, Kern has reduced the level of water recycling due to improved water quality. This should somewhat reduce the salt load in the water that may be released from the refuge.

The majority of water utilized on Kern NWR evaporates or percolates into the soil. The relatively small amount of water that is discharged is utilized on adjacent farmland or seeps into the soil in the Goose Lake Canal.

On Pixley NWR, the wetland units are also used for groundwater recharge thus no waters are discharged off the refuge. On the private wetlands, water is applied in early Fall and Winter for waterfowl hunting. Following the close of the hunting season, water is allowed to evaporate and percolate into the soil.

Management Practices at the Mendota WA are directed towards maintaining quality wetland habitat for migrating and wintering migratory birds, primarily waterfowl and shorebirds. These management practices are similar to those of other managed wetlands in the Valley.

Available Water Quality Information

Kern NWR monitors twice yearly for the following constituents:

- DO, EC, molybdenum phosphorus, pH, TDS, boron, sodium, arsenic, and selenium. Reports are available in the refuge files.

Discussion

The total acreage of managed wetlands in the Central Valley Watershed from Modoc NWR in the north to Kern NWR in the south is about 144,000 acres. These wetlands are principally located in the lower elevations of the various subbasins in which they occur. These low areas have traditionally served as the receiving lands for return flows from upland water users. This is especially true following the major alteration to historic flows for flood control and agriculture.

Water quality has been a concern of wetland managers for more than 50 years. This concern, however, was focused on water being used to manage wetlands rather than waters being discharged to downstream rivers. As a result, there is limited information available on water quality of wetland discharges. The majority of the available information is for wetlands in the Westside San Joaquin River Subbasin, San Luis NWR, Grassland RCD, and Volta, Los Banos, and North Grassland WAs.

The CVPIA has had a beneficial effect on reliability, quality, and management on a major portion of Central Valley wetlands. For the most part, quality of water available for wetland management has improved. Wetlands nationwide have been known as natural filtering systems for many constituents, and it is anticipated that over time the wetlands' authorized supplies for the CVPIA will also result in improved quality of return flows.

The management practices (MPs) that are utilized by wetland managers are essentially uniform throughout the Central Valley. The primary management objective is to provide quality wetland habitat for migrating and wintering populations of migratory birds, primarily waterfowl and shorebirds. Therefore, MPs are focused on meeting that objective. The principle type of wetlands managed are seasonal wetlands, either irrigated for waterfowl food production (swamp timothy/watergrass) or non-irrigated. Irrigated seasonal wetlands receive water one to three times between April and June each year depending on the food plants desired and geographic location of the area. These wetlands, along with non-irrigated seasonal wetlands, are then flooded in early fall and maintained through the winter until February or March when they are gradually drawn down to achieve desired soil temperatures for germination of desired food plants.

Other wetland types being managed include permanent year-round marsh units and semi-permanent wetlands. The semi-permanent wetlands, also known as brood ponds, are usually dewatered for two to three months around July of each year and may be re-flooded for the fall and winter waterfowl migrations. These two wetland types comprise about 10% of the total wetlands in the Central Valley Watershed.

Typical management of wetlands in past years did not consider the quality of return flows as a principle focus of any of the standard MPs. With a few minor exceptions, this is still the existing condition today. To better understand the water quality of return flows and whether wetlands and wetland MPs are impacting that quality, monitoring of inflow and outflow waters may be desirable. However, there are wetland managers who feel that due to the location of wetlands throughout the Valley, and the public trust responsibilities for the resources that utilize them, wetlands should be considered receiving waters of the State. Thus, water supplies that flow to and through wetlands, and used for management, should be held to the same standards as other receiving waters within the subbasin in which the wetlands are located.

Overall, the primary finding of the current existing conditions for Central Valley managed wetlands is that the information on water quality can be found where concerns have existed for many years. The information is primarily found for wetlands in the Westside San Joaquin River Subbasin. All the other subbasins have very limited information, if any, and MPs are not focused on improving the quality of discharged waters. However, some MPs may result in ancillary benefits to wetland return flows. A more in-depth review, as the Water Quality Program moves forward and the expected EIR is developed, may help in determining the overall role of wetlands in the larger-scale management of water supplies throughout the entire Central Valley Watershed.